SOUTHERN INSECT MANAGEMENT RESEARCH UNIT

USDA/ARS

Stoneville, Mississippi

Annual Report on Progress (CY 98)
and
Plans (CY 99)

CONTENTS

II. MISSION STATEMENT AND STAFF:

SOUTHERN INSECT MANAGEMENT RESEARCH UNIT
ARS/USDA, Mid South Area
P. O. Box 346
Stoneville, Mississippi 38776
Telephone: 601-686-5231
FAX: 601-686-5421

MISSION:

To develop new knowledge on the biology of field crop insects for development of new and improved control tactics and to establish fundamental principles for encouraging and using natural enemies more effectively. To develop and integrate insect suppression strategies into field crop systems that minimize the cost of plant protection, yet are ecologically acceptable. Specifically:

1. Elucidate the efficacy of indigenous predators and parasites, particularly those attacking the bollworm, *Helicoverpa zea*, tobacco budworm, *Heliothis virescens*, and tarnished plant bug, *Lygus lineolaris*.

2. Research and develop methods for augmenting parasite populations in management of insect pests of field crops, particularly parasitoids for control of *Heliothis/Helicoverpa*.

3. Develop new knowledge on biology and behavior of *Heliothis/Helicoverpa* spp. and beet armyworm, including use of entomopathogenic viruses in management of the latter.

4. Conduct basic biological and ecological research on plant bugs, particularly the tarnished plant bug, *Lygus lineolaris*, and cotton aphid, *Aphis gossypii*.

5. Develop monitoring and predictive technology through quantitative population ecology for field crop insect pests, particularly bollworm/budworm, tarnished plant bug, and cotton aphid.

6. Assess the role of early season host plants in the buildup of *Heliothis/Helicoverpa*, beet armyworm, and tarnished plant bug populations and devise new and innovative tactics for suppressing these populations, including use of entomopathogenic viruses and host destruction in area-wide management of these pests.

7. Develop chemical/biorational control tactics for use in integrated systems.

8. Develop chemical, biological, and other nonchemical methods for control of insect pests of corn.

9. Monitor for *Bt* resistance and develop resistance management tactics.

10. Locate, develop, and evaluate soybean cultivars resistant to insects.

11. Research and develop new management strategies in support of boll weevil eradication.

ARS PERSONNEL:

D. D. Hardee, Research Leader
(Supervisory Research Entomologist)
dhardee@ag.gov

STONEVILLE:

C. A. Abel, Research Entomologist
cabel@ag.gov
Vacancy, Biological Science Tech

L. C. Adams, Entomologist
ladams@ag.gov

T. G. Burton, Secretary OA
tburton@ag.gov
L. E. Taylor, OA Assistant
ltaylor@ag.gov

R. L. Ford, Biological Science Tech
rford@ag.gov
H. E. Winters, Biological Tech
G. J. Patterson, Insect Prod Worker

W. P. Scott, Research Entomologist
wscott@ag.gov
D. A. Adams, Entomologist
dadams@ag.gov

G. L. Snodgrass, Research Entomologist
gsnodgra@ag.gov
C. H. Lanford, Biological Science Tech
clanford@ag.gov

D. A. Streett, Research Entomologist
dstreett@ag.gov
D. W. Hubbard, Biological Science Tech
dhubbard@ag.gov

D. V. Sumerford, Research Entomologist
dsumerfo@ag.gov
W. L. Solomon, Entomologist
wsolomon@ag.gov

L. H. Williams, Research Entomologist
livy@ars.usda.gov
L. D. Price, Biological Science Tech
lprice@ag.gov

Vacancy, Research Entomologist
Vacancy, Biological Science Tech

Vacancy, Research Associate

J. D. Warren, Engineering Technician (Shop)

MISSISSIPPI STATE:

E. J. Villavaso, Research Entomologist
ejv1@ra.msstate.edu
W. L. McGovern, Entomologist
bmcgov@ra.msstate.edu
W. G. Kellum, Agric. Sci. Tech.
J. W. Stewart, Agric. Sci. Tech.

T. L. Wagner, Research Entomologist
wagner@csrumsu.ars.ag.gov
Vacancy, Agric. Sci. Tech.

III. SUMMARY OF RESEARCH PROGRESS FOR CALENDAR YEAR 1998:

A. *NARRATIVE:*

1. In-House

Production of insects for USDA-ARS research by the Stoneville Rearing Unit required maintenance of seven insect species: *Heliothis virescens*, *Helicoverpa zea, Anticarsia gemmatalis, Pseudoplusia includens, Spodoptera exigua, Cardiochiles nigriceps,* and *Microplitis croceipes*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA; Mississippi State, MS; Weslaco, TX; College Station, TX; and Gainesville, FL required production of 154,800 *H. virescens* pupae, 118,600 *H. zea* pupae, 39,800 *P. includens* pupae, 91,920 *A. gemmatalis* pupae, 32,975 *Spodoptera exigua* pupae, 53,077 *Cardiochiles nigriceps* cocoons, 34,599 *Microplitis croceipes* cocoons, 28,485 *Cotesia kazak* cocoons, 38,700,000 *H. virescens* eggs, 29,650,000 *H. zea* eggs, 19,900,000 *P. includens* eggs, 8,340,000 *A. gemmatalis* eggs, and 16,487,500 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 35,720 30-ml cups and 666-liter multicellular trays with artificial diet. Total diet mixed and dispensed in 1998 was 12,867 liters. Several short courses in insect rearing techniques were given to employees of Dupont Agricultural Enterprises, Newark, DE. Approximately 150 researchers located in 37 states, England, Canada, Japan, and Mexico participated in the Insect Distribution Program. **(R. L. Ford)**

Preliminary results of a study initiated in 1997 in a portion of the boll weevil eradication program near Collins, Mississippi, showed some promise for using bait sticks as a substitute for pinhead square/diapause sprays. Near fields surrounded by bait sticks from planting to August 1, 1997, traps caught one weevil at 2 of 6 fields and no weevils were detected in the fields in 1998. Of 6 fields surrounded by bait sticks from August 1 to frost in 1997, no weevils were caught in traps or detected in the field in 1998. In contrast, of 9 fields receiving no bait sticks, weevils were caught in traps and/or detected in 8 of the 9 fields. The test was repeated in 1998 and will be similarly evaluated in 1999. **(D. D. Hardee, L. C. Adams)**

Monitoring for resistance in *Bt* cotton to bollworm/tobacco budworm was continued for the 3rd year by subjecting 44 colonies (10 budworm, 34 bollworm) submitted by 14 cooperators from 9 states to MVP II overlays in diet. A slight shift in tolerance was detected in both species, but because of the low number of colonies tested, one more year of expanded testing will be necessary before concrete conclusions can be drawn. **(D. D. Hardee, D. V. Sumerford, L. C. Adams, W. L. Solomon)**

Results from a third year of testing for the best time to spray for cotton aphids failed to agree

with results from 1996-1997 in that treating at the 4- to 5-lf stage (pre-pinhead square) produced higher yields than spraying one week (full-grown square) and two weeks (bloom) later. However, no treatment provided cotton yields significantly higher than the untreated check, indicating that in 1998 under the conditions of this test, insecticide treatments for aphids were not needed. **(D. D. Hardee, L. C. Adams)**

Nineteen transgenic cotton varieties were compared to Sure-Grow 125 in unreplicated small plot tests near Elizabeth, Mississippi. No treatments were made for bollworm/budworm, whereas all plots received 10 applications of Vydate @ 0.25 AI/A for boll weevils/tarnished plant bugs. The 19 varieties averaged 35% higher yields than Sure-Grow 125 and differences ranged from +7% to +67%. **(D. D. Hardee, L. C. Adams)**

Several proprietary compounds from Novartis, Rhone-Poulenc, and Uniroyal Chemical were evaluated against cotton aphids and/or bollworm/budworm; yield records were obtained where possible. All data have been forwarded to all three companies. **(D. D. Hardee, L. C. Adams)**

We cooperated with scientists in the Southern Weed Science Research Unit in evaluating insect counts throughout the season in ultra-narrow-row (UNR) cotton. Another year's evaluations are needed, but preliminary results indicate that boll weevil numbers appear higher and more difficult to control in UNR than conventional cotton. There were no apparent differences in other insect numbers in the two systems. **(D. D. Hardee, L. C. Adams)**

In comparative tests of effectiveness of five insecticides, all materials significantly reduced numbers of beet armyworms when compared to an untreated check. Percent controls for each of the materials was Pirate - 97%, Tracer - 94%, Larvin - 81%, Spod-X - 77%, and Curacron - 71%. **(D. D. Hardee, L. C. Adams)**

Moth trap records in 1998 compared to 1997 collected at the same trap sites showed that (1) beet armyworm numbers were highest since 1995 (over 1.5 x 1997); (2) bollworms were 10% higher; and (3) tobacco budworms were almost double 1997, the first increase in the last 4 years. **(D. D. Hardee, L. C. Adams, D. W. Hubbard)**

Since 1992, we have made field collections of each generation (May through August) of bollworm/tobacco budworm for evaluation of response to five classes of insecticides in a spray chamber simulating field application conditions. As in the past three years, tobacco budworms became very difficult to control by the third and fourth generations (July and August) with all insecticides tested except Tracer®. Bollworms, however, showed no change in susceptibility to all classes of insecticides throughout the season. **(D. D. Hardee, L. C. Adams)**

An economic and entomological study of producing *Bt* and non-*Bt* cotton on fifteen farms that represent different regions of the Mississippi Delta began in 1998. This is a cooperative study between ARS and the Delta Research and Extension Center. Partial funding from Cotton Inc. began in 1998. A pilot study initiated in 1997 was used to establish cooperators and to purchase necessary equipment. Yields of *Bt* and non-*Bt* varieties were harvested, and information on insecticide costs of controlling insect pests on

In comparing the effectiveness of five insecticides, all materials significantly reduced numbers of beet armyworms when compared to an untreated check. Percent controls for each of the materials was Pirate - [illegible]%, Tracer - [illegible]%, Larvin - 81%, Spod-X - 77% and Confirm - 71%. (D. D. Hardee, L. C. Adams)

Moth trap captures in 1998 compared to 1997 collections at the same trap sites showed that (1) beet armyworm numbers were highest since 1995 (over 1.5 x 1997); (2) bollworms were 10% higher; and (3) tobacco budworms were almost double 1997, the first increase in the last 4 years. (D. D. Hardee, L. C. Adams, [illegible] W. Hubbard)

Since 1992, we have made field collections of each generation (May through August) of bollworm/tobacco budworm for evaluation of response to five classes of insecticides in a spray chamber simulating field application conditions. As in the past [illegible] years, tobacco budworms became very difficult to control in the third and fourth generations (July and August) with all insecticides tested except Tracer®. Bollworms, however, showed no change in susceptibility to all classes of insecticides throughout the season. (D. D. Hardee, L. C. Adams)

An economic and entomological study of producing Bt and non-Bt cotton on fifteen farms that represent different regions of the Mississippi Delta began in 1998. This is a cooperative study between ARS and the Delta Research and Extension Center. Partial funding from Cotton Inc. began in 1998. A pilot study initiated in 1997 was used to

and two weeks
treatment
[illegible] significantly higher
check, indicating that in
conditions of this test,
[illegible] were not

[illegible] worm; yield
[illegible] where possible. All data have been
[illegible] warded to all three companies.
[illegible] L. C. Adams)

[illegible] with scientists in the Southern
[illegible] Research Unit in evaluating
[illegible] throughout the season [illegible]
[illegible] (NBZ) cotton. Another year's

each variety from each farm was collected. On the majority of the 15 farms the cost of producing *Bt* was considerably less than non-*Bt*. On farms that planted NuCotn 33-B, yields were consistently higher than in the non-*Bt*. Yields obtained with other *Bt* varieties were mixed. **(W. P. Scott, G. L. Snodgrass, F. T. Cooke)**

The effects of thirteen different insecticides were evaluated for tarnished plant bugs and boll weevil control in NuCotn 33B cotton in replicated small plots. All treatments were compared to an untreated check. The better plant bug suppression was observed in plots sprayed with Regent, Monitor, Karate, and CGA2933. Highest yields were in treatments with Regent and CGA2933. **(W. P. Scott, G. L. Snodgrass)**

Regent (Fipronil) was evaluated in large plots (3-4 acres) for tarnished plant bug and boll weevil control. Treatments were applied both by air and ground under Section 18 (EUP) and were compared to other standard insecticides and an untreated control. In the aerial study, Regent and Vydate were very effective in controlling the plant bug and boll weevil. In the ground study, plant bug and weevil control was better with Regent than in Vydate and Baythroid treatments. Yield from treatments of Regent and Vydate applied by air and the untreated control were 805, 764, and 326 pounds of lint per acre, respectively. In the ground study, yields from Regent, Vydate, Baythroid and untreated control were 880, 742, 752, and 326 pounds of lint per acre, respectively. **(W. P. Scott, G. L. Snodgrass, D. A. Adams)**

A large field study was conducted to evaluate effects of seed treatments, in-furrow application of temik and imidacloprid, and side dress applications of temik in 3-acre plots on thrips and tarnished plant bugs in NuCotn 33B and Sure Grow 125 cotton. Infestations of thrips and plant bugs were low in 1998 and differences in populations among treatments were inconsistent. In the 125 variety, highest lint yields were the treatments with the 1.0 lb ai/acre rate of temik and temik in-furrow plus sidedress. In the NuCotn 33B, the highest yields were in treatments with temik in-furrow plus side dress and the imidacloprid. **(W. P. Scott, G. L. Snodgrass, D. A. Adams)**

A field test using sticky traps baited with virgin male or female tarnished plant bugs was repeated. The traps were placed in weedy fields with abundant wild hosts with good populations of plant bugs. Three treatments were used in the tests: an unbaited control, traps baited with 10 virgin males, and traps baited with 10 virgin females. In all previously published literature, males were not thought to produce an attractive pheromone, and the virgin females were consistently shown to attract males. In our test in 1997, results indicated that the male might be producing an aggregating pheromone attractive to both sexes. Male-baited traps captured significantly higher numbers of males ($P = 0.08$) and females ($P = 0.03$) than were captured on unbaited check traps. In 1998, female baited traps caught significantly higher numbers of males than check or male baited traps. Also, male-baited traps captured numerically higher numbers of males than check traps (about 4-fold higher) but this was only significant at $P = 0.13$. Male-baited traps again captured numerically higher numbers of females (2-fold) than unbaited check traps. Thus, both years indicated the possible presence of a male-produced aggregating pheromone. **(W. P. Scott, G. L. Snodgrass)**

[illegible] applications in [illegible] alone [illegible] and [illegible] plant bugs [illegible] 33 [illegible] Grow 125 cotton [illegible] and plant bugs [illegible] differences in populations and [illegible] 125 [illegible] yield [illegible] treatments [illegible] and [illegible] substances [illegible] 33B [illegible] highest yields were in [illegible] with [illegible] plus [illegible], [illegible] (W. P. Scott [illegible] Snodgrass, D. A. Adams)

A field [illegible] using sticky traps baited with virgin [illegible] females [illegible] was conducted. The traps were placed [illegible] with [illegible] populations of [illegible] bugs. The [illegible] were [illegible] as unbaited [illegible] traps [illegible] and [illegible] baited [illegible] 11 [illegible] females. In [illegible] previously published [illegible] and [illegible] pheromone [illegible] virgin females [illegible] consistently [illegible] test in 1997, results indicated [illegible] male [illegible] producing [illegible] pheromone [illegible] in both [illegible] baited traps captured significantly higher numbers of males ([illegible] = .08) and females ([illegible] 0.03) than were captured [illegible] unbaited check traps. In 1998, female baited traps caught significantly higher numbers of males than [illegible] male baited traps. Also, male baited traps captured numerically higher numbers of males than check traps [illegible] but this was only significant at P = 0.1. [illegible] baited traps again captured numerically [illegible] numbers of females [illegible] than [illegible] check traps. Thus, both years [illegible] the possible presence of a male [illegible] pheromone.

[illegible] each farm was collected. [illegible] variety of the 15 farms the cost of [illegible] was considerably less than [illegible] that planted [illegible] 33-B [illegible] consistently higher than in the [illegible] Yields [illegible] were [illegible] Scott, [illegible] Snodgrass, E. T. Cooke)

[illegible] different insecticides [illegible] plant bugs and [illegible] 33B cotton [illegible] plots. All treatments were [illegible] to untreated check. The better [illegible] was observed in plots [illegible] Regent, Mustang, Karate, and [illegible] 33. Highest yields were in treatments [illegible] and CGA293 [illegible] (W. P. Scott, [illegible] Snodgrass)

[illegible] (Tracer) was evaluated in large plots [illegible] for [illegible] plant bug and boll [illegible] control. The treatments compared both [illegible] under Section [illegible] (1997) [illegible] compound [illegible] control. In the [illegible] study, [illegible] Vydate were very effective in [illegible] plant bug and boll weevil. In [illegible] study, plant bug and [illegible] control [illegible] with [illegible] Vydate and [illegible] treatments. Yield from treatments [illegible] Vydate applied [illegible] the [illegible] control were 805, [illegible] and 326

The possibility of using tarnished plant bugs possessing an eye mutation for bright red eyes (normal eyes are dark reddish brown) in movement studies was investigated in 1998. Mated adults 7-10 days old were released into areas with abundant wild host plants in April and May. A total of 1,900 were released in 3 releases of 800, 700, and 400 adults by shaking their holding cages onto wild hosts in the center of each release area. Wild hosts around the release sites were then sampled at various time intervals over a 2-3 wk period in an effort to recapture the adults or their offspring. Over 3,000 adults and nymphs were collected in which only 1 red-eyed adult was found. To determine why the releases were not working, adults were caged on mare's tail, *Erigeron canadensis*, to see if the red-eyed adults could survive and produce offspring on a wild host plant. Results showed mare's tail to be a suitable host and offspring were produced. In a second test, normal-eyed wild adults and red-eyed adults were tested for flight ability by placing them on a 5 X 5 inch platform on the end of a 3 ft stake which was driven into the ground. Flight of both groups from the platform was the same. In October, 450 mated red-eyed adults were released into a large field of goldenrod, *Solidago altissima*. These adults were fed goldenrod blossoms in addition to green beans for 1 wk prior to their release to acclimate them to their main food source in the release area. Release was made on 8 October and samples from the goldenrod in the field were taken on 9, 13, 16, 29, and 30 October, and 5 November. On October 29 (21 days after their release), 2 red-eyed adult males and 1 red-eyed adult female were captured. These adults were dark colored (not light which would indicate a new adult) and were part of the original red-eyed adults released. One red-eyed 5th instar nymph was captured on October 30. A total of over 2,800 normal-eyed nymphs and adults were captured in the study. These results were encouraging, and the test will be repeated using a much larger number of bugs in 1999. **(G. L. Snodgrass)**

Studies on several aspects of reproductive diapause in the tarnished plant bug were begun in 1998. Beginning in February, adults were collected from wild hosts and sexed in the laboratory to determine sex ratios. In February-March this ratio was 74.8% female to 25.2% male (n=1553). In April the ratio was calculated from the mixture of overwintered and F1 adults collected, and it was 52.8% female to 47.2% male (n=797). In the period April-October the ratio was 51.8% female to 48.2% male (n=3385). The ratios for November-January will be done this fall and winter. Adults were collected in November and brought into the laboratory to determine the percentage in diapause and the percentage of those in diapause which are mated. No results are available, but these tests will continue in December-March and in August-October 1999. On February 27, 1998 overwintered adults (out of reproductive diapause) were brought into the lab and egg lay by the overwintered females was studied and compared to egg lay in a laboratory colony. Samples of wild hosts in late-February through March found no nymphs in 1998 until the 4th week in March. So, it is unlikely that the overwintered adults used in the laboratory study had laid any eggs prior to their being brought into the laboratory. Egg lay (number of eggs laid per female per day) in the 2 groups was different. Overwintered females laid the most eggs in the first week, then egg lay declined each succeeding week. Egg lay peaked in the laboratory colony at 16-18 days then slowly declined. Mortality in

overwintered females was 40% in the 1st week and reached 90% after 3 weeks. Mortality in the lab colony was 7% in the first week and did not reach 90% until day 52. **(G. L. Snodgrass)**

Compounds with possible activity against tarnished plant bugs were tested in laboratory bioassays this spring. The compounds are from Mycogen Corporation and are being tested under a secrecy agreement. **(G. L. Snodgrass)**

A large area-wide experiment designed to evaluate control of tarnished plant bugs in cotton by reduction in numbers of wild host plants available for plant bug population buildups in the spring was conducted in 1998. Four areas (3 in Washington and 1 in Sunflower Counties), each 3 X 3 mi in size, were used. Three of the areas (checks) received no treatment, the 4th area (treated) was treated in April with Trimec (broad leaf weed killer), Roundup, or mowing. Treatments were applied only to those marginal areas by roads, fields or ditches, in which good stands of wild host plants were found. The objective of the treatments was to eliminate the best areas of wild hosts, but not all wild hosts. Prior to treatment, wild hosts were sampled for plant bugs in all 4 areas. In addition, densities of the most abundant wild hosts were determined. Treatments were applied in mid-April. Plant bug populations and plant densities were determined for wild hosts in the first 2 weeks of April, and again in mid-May. Adult plant bugs found in the samples were mainly F_1 with a few overwintered adults at the time the treatments were applied. In June and July through the 1st week in August cotton fields were sampled for plant bugs each week. In the treated area, 14 fields were sampled, while a total of 33 fields were sampled in the 3 check areas. All fields were chosen at random from all fields in each area each week. Ten early-planted group IV or V soybean fields (4 in the treated area and 2 in each check area) were sampled for plant bugs weekly during June and July. In addition to normal sampling, extra samples were taken in cotton fields that bordered corn or soybean. These edge samples were taken within 25 rows or about 100 feet from the edge where the cotton bordered corn or soybeans. The most abundant wild hosts found in the 4 areas were cutleaf geranium, cutleaf evening-primrose, showy evening primrose, sour dock, vetch, calley pea, bur clover and white clover. As expected, areas treated with Trimec had a significant reduction in numbers of wild hosts. Numbers of hosts per square meter averaged 7.85 in the treated area as compared to 25.83 in the 3 check areas. Roundup was used only as a spot treatment for smaller areas of hosts and was applied using spray equipment mounted on all-terrain vehicles. One large section of wild hosts found along a road in the treated area was mowed with a tractor and bush-hog. This area had regrown when it was sampled ca. 4 weeks after treatment and had abundant hosts and plant bugs. It was retreated with Trimec. Mowing, to be effective, will have to be repeated 2-3 times at about 2 week intervals. Numbers of plant bugs found on wild hosts in the treated areas were not significantly different in the 4 areas in the samples taken prior to treating the treated area. After treatment, numbers of plant bugs on the wild hosts in the treated area were 4-fold lower than in the check areas. Most samples taken in cotton in June in the treated and 3 check areas had plant bug counts of 0. This made statistical analyses of the data impossible since the data were not (and could not be successfully transformed) normally distributed. A light infestation of plant bugs

were sampled in the 3 check areas. All fields were chosen at random from all fields in each area each week. Ten early planted group IV or V soybean fields (4 in the treated area and 2 in each check area) were sampled for plant bugs weekly during June and July. In addition to normal sampling, extra samples were taken in cotton fields that bordered corn or soybean. These edge samples were taken within 25 rows or about 100 feet from the edge where the cotton bordered corn or soybeans. The most abundant wild host found in the 4 areas were cutleaf groundsel, cutleaf evening-primrose, showy evening primrose, [illegible] dock, vetch, [illegible] clover and white clover. As expected, areas treated with Trimec had a significant reduction in numbers of wild hosts. Numbers of hosts per square meter averaged 7.85 in the treated area as compared to 25.88 in the 3 check areas. Roundup was used only as a spot treatment for smaller areas of hosts and was applied using spray equipment mounted on all-terrain vehicles. One large section of wild hosts found along a road in the treated area was mowed with a tractor and bush-hog. This area had regrown when it was sampled ca. 4 weeks after treatment and had abundant hosts and plant bugs. It was retreated with Trimec. Mowing, to be effective, will have to be repeated 2-3 times at about 2 week intervals. Numbers of plant bugs found on wild hosts in the treated area were not significantly different than the checks in the samples taken prior to treating the treated area. After treatment, numbers of plant bugs on the wild hosts in the treated area were 4-fold lower than in the check areas. Most samples taken in cotton in June in the treated and 3 check areas had plant bug counts of 0. This made statistical analyses of the data impossible since the data were zero (and could not be successfully transformed) normally distributed. A light infestation of plant bugs

[illegible] planted [illegible] reached [illegible] 40% in the 1st [illegible] and reached 91% after 3 weeks. [illegible] in the [illegible] colony was 79% at the start [illegible] and did not reach 90% until day 52 [illegible] treated [illegible])

[illegible] with [illegible] activity against [illegible] bugs were tested in laboratory [illegible] spring. The compounds are [illegible] Corporation and are being [illegible] agreement.

[illegible] experiment designed to [illegible] control of tarnished plant bugs in [illegible] by reduction in numbers of wild host [illegible] available for plant bug populations [illegible] in the spring was conducted in 199[illegible] (3 in Washington and 1 in [illegible] counties), each 2 X [illegible] mi in size. Three of the areas (checks) [illegible] no treatment. The 4th area (treated) [illegible] in April with Trimec (broadleaf [illegible]), Roundup, or [illegible] were applied only to those [illegible] areas by roads, fields, or ditches in [illegible] stands of wild host plants were [illegible] objective of the treatments was to [illegible] cost of [illegible] rows [illegible] not [illegible] Prior to treatment, wild hosts

did occur in cotton in mid-to late-July in all 4 areas. The low numbers of plant bugs found in June were at least partly caused by insecticide treatments of most fields for large numbers of boll weevils. This masked any early-season effect that treatment of the wild hosts may have had. Samples taken in the edge of cotton fields where they bordered soybeans showed that the soybeans had no influence on numbers of plant bugs in the cotton field edge. Edge samples taken in cotton by corn during July showed that corn did have a significant effect on numbers of plant bugs in cotton. Samplers were significantly more likely to find plant bugs in the field edge by corn as they were in samples taken in the rest of the field. Plant bugs were found in all 10 of the early soybean fields sampled. The highest population in a single field was estimated at 1350 adults and nymphs per acre in early-June. All 10 fields averaged 320 adults and nymphs per acre in early June. Blooming in the early planted soybeans stopped by the end of June, and by the 2nd week in July plant bugs had dispersed from the soybeans. Although corn was not sampled in the experiment, plant bugs were found reproducing in corn by G. L. Snodgrass and other researchers in 1998. The ability of plant bugs to reproduce in corn and soybeans complicates its control by elimination of early season wild hosts. If wild hosts are treated when F_1 adults have already been produced (as they were in the present test), these adults live long enough (they can live and lay eggs for 50 days in the laboratory) to move from the treated hosts to other ones, such as corn or soybeans. However, overwintered adults are shorter lived (about 3 weeks in the laboratory) and it is these adults that the treatments should target. Treatments of wild hosts should be made in March when samples have determined that the overwintered generation is active and laying eggs. **(G. L. Snodgrass, W. P. Scott, D. D. Hardee)**

A survey was conducted in August to determine if plant bugs in the Delta had increased insecticide resistance to Orthene. Plant bugs were collected from wild hosts (mainly mare's tail) in the Delta at 5 locations in Arkansas, 2 in Louisiana, and 13 in Mississippi. Resistance to Orthene was determined using a glass vial bioassay in which 210-300 adults from each location were tested at different concentrations of Orthene to determine an LC_{50} for Orthene for bugs from each location. These LC_{50}'s were compared to an LC_{50} value for Orthene determined using susceptible bugs collected near Crossett, Arkansas. The highest amounts of resistance found to Orthene was only 3-fold higher than the susceptible bugs. These results indicated that Orthene is still an effective insecticide for plant bug control in the Delta. **(G. L. Snodgrass, W. P. Scott)**

A critical factor in the effectiveness of insect viruses as microbial control agents is their short persistence on leaf surfaces. The objective of this study was to develop and evaluate additives to spray formulations that may increase virus persistence, and thus provide more effective microbial control agents. A small field test was conducted to determine whether field persistence of *Anagrapha falcifera* nucleopolyhedrovirus (AnfaNPV) could be increased using different starch/lignin formulations. **(D. A. Streett, M. McGuire)**

The area-wide test was conducted this field season to assess the effectiveness of a lower application rate of *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) (Gemstar^{TM}) with a virus

[illegible] and feeding eggs. (G. L. Snodgrass, W. P. Scott, D. B. Hardee)

A survey was conducted in August to determine if plant bugs in the Delta had increased in resistance to Orthene. Plant bugs were collected from wild hosts (mainly [illegible]) in the [illegible] locations [illegible] in Arkansas, 2 in Louisiana, and 13 in Mississippi. Resistance to Orthene was measured using a glass vial bioassay, in which 270-300 adults from each location were tested at different concentrations to determine [illegible] for Orthene for bugs from each location. These [illegible] were compared to an LC_{50} value for Orthene determined using susceptible bugs collected near Crossett, Arkansas. The highest amount of resistance found to Orthene was only [illegible] higher than the susceptible bugs. These results indicated that Orthene is still an effective insecticide for plant bug control in the Delta. (G. L. Snodgrass, W. P. Scott)

A critical factor in the effectiveness of insect viruses as microbial control agents is their short persistence on leaf surfaces. The objective of this study was to develop and evaluate additives to spray formulations that may increase virus persistence, and thus provide more effective microbial control agents. A small field test was conducted to determine whether field persistence of *Autographa californica* nucleopolyhedrovirus (AcMNPV) could be increased using different [illegible] formulations. (D. A. Streett, [illegible])

The area-wide test was conducted this field season to assess the effectiveness of a lower application rate of *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) (Gemstar™) with a virus

[illegible] early in all [illegible] fields of [illegible] at least partly caused by [illegible] corn fields for large [illegible] weevils. This mushed any [illegible] fact that treatment of the wild [illegible] had. Samples taken in the [illegible] cotton [illegible] showed that the soybeans had no [illegible] on numbers of plant bugs in the [illegible] Edge samples taken in [illegible] by corn [illegible] July showed that corn [illegible] a significant effect on numbers of [illegible] in cotton. Samples were [illegible] likely to find plant bugs in [illegible] corn as they were in samples [illegible] rest of the field. Plant bugs were [illegible] all 10 of the early soybean fields [illegible] The highest population in a single [illegible] 350 adults and nymphs [illegible] early June. All 10 fields averaged [illegible] and nymphs per acre in early June. [illegible] in the early planted soybeans [illegible] by the end of June and by the end [illegible] July, plant bugs had disappeared from [illegible] Although corn was not sampled [illegible] experiment, plant bugs were found [illegible] feeding in corn by G. L. Snodgrass and [illegible] in 1993. The ability of plant [illegible]

[illegible] its control by elimination of early [illegible] hosts. If wild hosts are treated [illegible] have already been produced [illegible] the present test) these adults [illegible] (they can live and lay eggs [illegible] the laboratory) to move from [illegible] treatment, [illegible]

enhancing agent on the emergence of Heliothine adults from early season wild geranium. A circular treatment area with a 7.5 mile radius was established near Bourbon, MS and encompassed approximately 30,000 acres. Aerial application of the bollworm virus was applied at a rate of 2.47×10^{11} occlusion bodies (OB's) per ha to the entire area. Adult emergence was reduced significantly in artificially-infested enclosure cages treated with the virus. Pheromone trap data suggested that total moth emergence was reduced 52% when compared with moth emergence in untreated areas. **(D. A. Streett, D. D. Hardee)**

A study was conducted to determine the intraplant distribution of beet armyworm (BAW), *Spodoptera exigua* on *Bt* and non-*Bt* cotton. In addition, a discriminating dose was determined from bioassays for BAW, and will be used to assess the potential for resistence to *Bacillus thuringiensis* in successive generations of BAW. **(D. A. Streett)**

Preliminary evidence from a field study initiated to evaluate the impact of lower rates of *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) against *H. zea* on *Bt* cotton suggests that lower than recommended rates of HzSNPV may be efficacious. **(D. A. Streett, J. Mulrooney)**

Field populations of cotton bollworm and tobacco budworm were monitored for their tolerance to the *Bt* toxin CryIA(c). Quantitative genetic methods and traditional bioassays were used to look at differences in tolerance among and within populations of Heliothines from across the eastern U.S. cotton belt. Preliminary analyses of these data show that tolerance by CryIA(c) has a heritable component. Some evidence for a small shift in the tolerance of cotton bollworm from 1997 to 1998 is present. Selection experiments in the laboratory found that tolerance to CryIA(c) could be improved in bollworm populations. **(D. V. Sumerford)**

The toxicity of Boll Weevil Attract and Control Tubes (BWACT's) has been measured by placing weevils on tubes for specified short periods (usually 30 sec.). Recent observations in Texas, especially on tubes in storage for extended periods of time, caused us to re-examine that technique. With tubes in storage for about 1.5 years, significantly fewer weevils that alit on the tubes died than weevils placed on tubes. Later tests with more recently manufactured tubes showed similar mortalities between the two types of evaluation. The most recent tubes tested killed weevils for only four weeks compared with a 6-week period in years past. **(E. J. Villavaso, W. L. McGovern)**

Data collection on diapause termination and effect of the host on whether or not a weevil develops diapause characteristics continues. We are gaining a clearer understanding of the course of diapause termination and host effect. **(E. J. Villavaso, T. L. Wagner, W. L. McGovern)**

The diapause development model formulated in 1996-97 was used by eradication officials in Zone 4 of Mississippi during the late summer and fall of 1997. This model predicts spray intervals for diapause control applications. During 1998 we were requested to run the model for Zones 2, 3, and 4 in Mississippi and Zones 1, 2, and 3 in Tennessee. Running the model for this many sites would have been very time consuming using the original SAS research version of the

heritable component. Some evidence for a small shift in the tolerance of cotton boll weevil from 1997 to 1998 is present. Selection experiments in the laboratory found that tolerance to Cry1A(c) could be increased in boll weevil populations. (D. V. Sumerford)

The toxicity of Malathion Weevil Attract and Control Tubes (BWACT) [illegible] has been assessed by placing weevils in tubes for prescribed short periods (usually 30 sec.). Recent observations [illegible] tubes in storage for [illegible] periods of time caused us to re-evaluate this technique. With tubes [illegible] about 1.5 yrs [illegible] significantly fewer weevils that came in the tube died than were [illegible] fresh tubes. Later tests with more recently [illegible] tubes showed similar [illegible] between the two types of [illegible]. The more recent tubes [illegible] killed weevils for only four weeks compared with a 6-week period [illegible] (E. J. Villavaso, W. L. McGovern)

Fate Collection of [illegible] reproductive and [illegible] effect of the host [illegible] develops diapause [illegible] We are gaining a clearer understanding of the causes of diapause [illegible] and host effect. (E. J. Villavaso, J. E. Wagner, W. L. McGovern)

The diapause development model [illegible] in 1996-97 was used by cotton [illegible] in Zone 4 of Mississippi during the late summer and fall of 1997. This model predicts spray intervals for diapause control applications. During 1998 we were requested to run the model for Zones 2, 3, and 4 in [illegible] and Zones 1, 2, and 3 in [illegible] Running the model [illegible] the many [illegible] have been very time consuming [illegible] research version of the

[illegible] on the emergence of [illegible] from early season adult [illegible] circular treatment area with a [illegible] was established [illegible] which encompassed approximately 30,000 [illegible] aerial application of the boll weevil virus [illegible] at a rate of 2.47×10^{9} occlusion bodies (OB's) per ha to the [illegible] Adult [illegible] was reduced significantly in [illegible] emergence cages treated [illegible] trap data [illegible] and [illegible] was reduced 37% [illegible] compared with moth emergence in [illegible] areas. (D. A. Streett, [illegible])

[illegible] was conducted to determine the [illegible] distribution of host and [illegible] of Spodoptera exigua on [illegible] and non-[illegible] In addition, a discriminating [illegible] obtained from bioassays for BAW, and [illegible] to assess the potential for [illegible] to decline [illegible] in [illegible] generations of B[illegible] [illegible])

[illegible] evidence from a field study [illegible] to [illegible] the impact of [illegible]

code. We therefore translated the research code into C during 1998, making it far easier to run the model on more sites each day. This new code can also be used by "non-experts" to predict diapause control spray intervals throughout the late summer and fall. Model results were FAXed to 5 people every other day during August-October. **(T. L. Wagner)**

We conducted tests with a micro-respirometer delineating age-, sex-, and food-dependent respiration rates of reproductive and diapausing boll weevils. The respirometer was obtained, setup, and calibrated in late summer 1997. During the remainder of that field season, we tested respiration rates of no fewer than 56 females and 50 males; e.g., CO_2 levels were measured at 1-sec intervals over 6-min periods for each individual per observation, with as many as 22-24 observations taken at different weevils ages. This work created a tremendous amount of "raw" data in ppm CO_2/sec, for which we hired a student computer programmer in early 1998 to transform the data (into μl/mg/hr CO_2) and then begin to analyze it. Preliminary observations indicate that CO_2 rates of reproductive females remain relatively high throughout most of their adult lives, dropping off only as they approach death. The rates of diapausing females drop off during the initial feeding (prediapause) period, after which they asymptote at low levels. The rates remain low until the female begins to break diapause, whereupon the rates return to the higher levels typical of reproductive animals. Age-dependent respiration rates of males were similar to females, although it appears that both reproductive and diapausing males have somewhat lower rates than females. Feeding on squares or bolls did not appear to influence respiration rates. The ongoing analysis was halted with the initiation of 1998 experiments designed to replicate and expand on last year's work. **(T. L. Wagner, E. J. Villavaso)**

We setup and conducted a method of overwintering test in 1997 to determine whether boll weevils spend the winter in diapause, *per se*, or in a state of post-diapause quiescence. These data were entered into the computer during 1998, but analysis has not yet begun. **(T.L. Wagner, E. J. Villavaso)**

We setup and conducted two food preference tests in 1997 to determine whether prediapausing adults prefer to feed on squares or bolls, and more importantly, how quickly diapausing females break diapause. These data were entered into the computer during 1998, but analysis has not yet begun. Preliminary observations indicate that prediapausing adults prefer to feed on squares over bolls. The tests were replicated and expanded in 1998, with hopes of learning how temperature influences female diapause development and termination. **(T. L. Wagner, E. J. Villavaso)**

We setup and conducted several tests examining the effects of food quality on boll weevil diapause in 1997. For example, we fed adults leaves immediately after emergence for 3-, 7-, 10-, and 14-d, and bolls thereafter until day 23, to see if a period of sub-optimal diet would influence their ability to achieve diapause. Preliminary observations indicate that weevils initially fed leaves attained lower diapausing rates (i.e., more were reproductive) than control weevils fed bolls throughout their adult life. We also put weevils on large bolls in the field to see if they could go into diapause on "low-quality" food. Most were able to achieve diapause. Some of these tests were repeated in 1998. **(T. L. Wagner,**

of 1997 experiments designed to replicate and expand on last year's work. (T. L. Wagner, E. J. Villavaso)

We setup and conducted a method of overwintering test in 1997 to determine whether boll weevils spend the winter in diapause, as seen in a state of post-diapause quiescence. These data were entered into the computer during 1998, but analysis has not yet begun. (T. L. Wagner, E. J. Villavaso)

We setup and conducted two food preference tests in 1997 to determine whether prediapausing adults prefer to feed on squares or bolls, and more importantly, how quickly diapausing females break diapause. These data were entered into the computer during 1998, but analysis has not yet begun. Preliminary observations indicate that prediapausing adults prefer to feed on squares over bolls. The tests were replicated and expanded in 1998, with hopes of learning how temperature influences female diapause development and termination. (T. L. Wagner, E. J. Villavaso)

We setup and conducted several tests examining the effects of food quality on boll weevil diapause in 1997. For example, we fed adults squares immediately after emergence for 3-, 7-, 10-, and 14-d, and bolls thereafter until day 25, to see if a period of sub-optimal diet would influence their ability to achieve diapause. Preliminary observations indicate that weevils initially fed squares attained lower diapausing rates (i.e., more was reproductive) than control weevils fed bolls throughout their adult life. We also put weevils on large bolls in the field to see if they could go into diapause on "low-quality" food. Most were able to achieve diapause. Some of these tests were repeated in 1998. (T. L. Wagner,

[illegible] the research [illegible] during 1998 making [illegible] the model on more sites each day. This [illegible] can also be used by "non-experts" to [illegible] diapause control spray intervals [illegible] summer and fall. Model [illegible] Xed to 5 people every other [illegible] October. (T. L. Wagner)

[illegible] a micro-respirometer [illegible] and food-dependent [illegible] reproductive and [illegible] tests. The respirometer [illegible] sensor array, and calibrated in late [illegible] During the remainder of that [illegible] we tested respirometer of so [illegible] females and 50 males, e.g., CO_2 [illegible] measured at 1-sec intervals over [illegible] for each individual per [illegible] with as many as 22-24 [illegible] taken at different lifestyle ages, [illegible] created a tremendous amount of [illegible] in ppm CO_2/sec, for which we [illegible] computer programmer in early [illegible] to transform the data (into μl/mg/h), [illegible] then begin to analyze it. [illegible] observations indicate that CO_2 [illegible]

[illegible] most of their adult lives, [illegible] only as they approach death. [illegible] diapausing females drop off [illegible] feeding/reproduction), mixed, [illegible] very low levels. The [illegible] low until the female begins to [illegible]

E. J. Villavaso)

Preliminary studies were conducted on biological control of *Lygus lineolaris* by the egg parasitoid, *Anaphes iole*. Research objectives addressed aspects of the wasp's biology critical to the success of a conservation/augmentation biological control program. The first objective was to determine if perennial plants adjacent to agricultural fields harbor overwintering *A. iole*. More than 125 collections (20 species from 14 families) were made at six sites in the Delta. Collections were made in the late winter and consisted of the previous season's growth. However, no *A. iole* was reared from this plant material. These results suggest that *A. iole* does not use a 'host alternation' strategy associated with perennial vegetation. The second objective was to determine if the spring emergence of the wasp is synchronized with *L. lineolaris* oviposition. Results from sticky trap data indicate that *A. iole* emergence is synchronized with the onset of *L. lineolaris* oviposition in the spring. A third objective was to develop a better understanding of the weed hosts of *L. lineolaris* that are also utilized by *A. iole*. Collections were made in the spring and fall from common weed species known to support *L. lineolaris*. *A. iole* was reared from *Rumex crispus* (sour dock), *Oenothera speciosa* (showy evening primrose), and *Ambrosia trifida* (giant ragweed). Additionally, data from the literature were used to summarize known associations between *A. iole* and host plants of *L. lineolaris*. The results indicate that at least 14 *L. lineolaris* hosts from which *A. iole* have been reared occur in the Delta. This information is important both for conservation and augmentation of *A. iole* populations in the Delta. **(L. Williams)**

A study was conducted in a commercial cotton field to determine the effect of distance from non-crop habitat on parasitism of *Helicoverpa zea* and *Heliothis virescens* larvae. The study was conducted in an 80-acre non-*Bt* cotton field bordered on one side by grain sorghum, on two sides by *Bt* cotton, and on one side by a creek with natural vegetation. Seven transects were established along a 500 m portion of the field edge adjacent to the natural vegetation. Each transect extended into the field perpendicular to the edge. Sample stations were established on each transect at 0 (field edge), 20, 100, and 500 m from the field edge. At each station 50 contiguous cotton plants were selected. One 3rd instar *H. zea* larva was placed on the terminal of 25 contiguous cotton plants; 3rd instar *H. virescens* were similarly placed on the other 25 plants. These sentinel larvae were recovered 3 days later, placed in diet cups, and held at 28°C until emergence of a wasp or moth. Sentinel larvae were established nine times during the growing season. Approximately 10% of the sentinel larvae were recovered, and of these more than 50% succumbed before parasitism could be determined. Data were thus pooled across dates. Parasitism of *H. zea* by *Microplitis croceipes* was rare (<1%). Parasitism of *H. virescens* by *Cardiochiles nigriceps* averaged ca. 45% across all distances. However, parasitism was independent of distance from the field edge ($P>0.05$). While preliminary, these results are promising because they suggest that *C. nigriceps* is capable of substantial parasitism in cotton far from non-crop habitats that may serve as refuges. **(L. Williams)**

As a requisite to an investigation of parasitoid dispersal, a pilot study was conducted to validate a novel marking technique. The

A study was conducted in a commercial cotton field to determine the effect of distance from non-crop habitat on parasitism of *Helicoverpa zea* and *Heliothis virescens* larvae. The study was conducted in an 83-acre [illegible] field bordered on one side by grain sorghum, on two sides by [illegible] cotton, and on one side by a river with natural vegetation. Seven transects were established along a 500 m portion of the field edge adjacent to the natural vegetation. Each transect extended into the field perpendicular to the edge. Sample stations were established on each transect at 0 (field edge), 20, 100, and 500 m from the field edge. At each station 50 contiguous cotton plants were selected. One 3rd instar *H. zea* larva was placed on the terminal of 25 contiguous cotton plants; 3rd instar *H. virescens* were similarly placed on the other 25 plants. These sentinel larvae were recovered 3 days later, placed in diet cups, and held at 27°C until emergence of a wasp or moth. Sentinel larvae were established nine times during the growing season. Approximately 10% of the sentinel larvae were recovered, and of these more than 50% succumbed before parasitism could be determined. Data were thus pooled across dates. Parasitism of *H. zea* by *Microplitis croceipes* was rare (<1%). Parasitism of *H. virescens* by *Cardiochiles nigriceps* averaged ca. 45% across all distances. However, parasitism was independent of distance from the field edge ($P>0.05$). While preliminary, these results are promising because they suggest that *C. nigriceps* is capable of substantial parasitism in cotton far from non-crop habitats that may serve as refuges. (L. Williams)

As a requisite to an investigation of parasitoid dispersal, a pilot study was conducted to validate a novel marking technique. The

[illegible]

[illegible] studies were conducted on [illegible] control of *Lygus lineolaris* by the [illegible] field, *Anaphes iole*. Research [illegible] ives addressed aspects of the wasp's [illegible] to the success of a [illegible] augmentation biological control [illegible]. The first objective was to determine [illegible] perennial plants adjacent to agricultural [illegible] shelter overwintering *A. iole*. More than [illegible] collections [illegible] from [illegible] families) [illegible] made at six sites in the Delta. [illegible] made in the late winter and [illegible] of the previous season's growth. [illegible] lodged [illegible] removed from the [illegible]. These results suggest that *A. iole* [illegible] use a 'host alternation' strategy [illegible] with perennial vegetation. The [illegible] objective was to determine if the [illegible] emergence of the wasp is synchronized [illegible] *L. lineolaris* oviposition. Results from [illegible]

[illegible] synchronized with the onset of *L. lineolaris* [illegible] in the spring. A third objective [illegible] a better understanding of the [illegible] of *lineolaris* that are also [illegible] *A. iole*. Collections were made to [illegible] and [illegible] common weed species [illegible] support *L. lineolaris*. *A. iole* was [illegible]

objective was to determine the retention of animal protein labels by *M. croceipes* wasps under field conditions. Wasps (<2 days old) were obtained from the SIMRU Insect Rearing Facility and were provided with honey and water *ad libitum*. A medical nebulizer was used to mist wasps with 1.0 mg/ml rabbit immunoglobulin (IgG) or chicken IgG. A third group of wasps was treated with fluorescent pink Day-Glo dust. Marked wasps were immediately released in separate cages (corresponding to the label) in a commercial soybean field. Live wasps were retrieved up to 9 days after being caged. A double antibody sandwich ELISA was performed on each live wasp collected from cages with IgG-labeled insects. Wasps recovered from the dust treatment were examined at 10x under a dissecting microscope for 1 minute and scored for presence or absence of dust. Average high and low air temperatures during the study were 36°C and 20°C, respectively. Precipitation (0.04") was recorded ca. 30 hours after wasps were caged. Wasps did not retain either protein label beyond 1 day after treatment. However, Day-Glo dust had 100% retention throughout the study. Clearly, technical hurdles must be overcome before IgG marking can be used to study parasitoid dispersal in the Delta. **(L. Williams)**

2. Extramural

E. I. Dupont de Nemours & Co. has several genetically-modified baculoviruses undergoing development that infect insect pest species of cotton. These genetically-modified viruses should provide better protection to cotton and offer another tactic to an integrated pest management program. Field activity and stability of the recombinant viruses were evaluated in small scale trials on cotton. Data were collected to evaluate a) percent larval infection, b) larval numbers, and c) crop damage. A non-target study assessed the impact of genetically-modified viruses on the abundance of non-target arthropods. **(D. A. Streett, D. D. Hardee, G. L. Snodgrass)**

A study was conducted with the University of Arkansas to assess the effect of host plant on the persistence of the *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) on six host plants; white clover, *Trifolium repens;* crimson clover, *Trifolium incarnatum*; velvetleaf, *Abutilon theophrasti;* soybean, *Glycine max;* geranium, *Geranium dissectum*; and cotton, *Gossypium hirsutum*. All virus treatments were equally effective with >85% mortality recorded at the 0 day sampling date. Virus inactivation was greatest on cotton foliage with < 44% OAR observed at 1 d post-application at the highest virus application rate. Inactivation of *H. zea* SNPV on wild host plants and soybean was not as rapid with some virus activity remaining at 5-7 d post-application. The percentage of original virus activity was positively related to virus application rate. **(D. A. Streett, G. Felton, S. Y. Young)**

A field cage study was initiated to evaluate the efficacy of two rates of a genetically-modified virus for *H. virescens* against three commercially available treatments for the control of *H. virescens* of cotton. **(D. A. Streett)**

activity and viability of the recovered viruses were evaluated in small scale trials on cotton. Data were collected on a) [illegible] percent larval infection, b) larval counts and c) crop [illegible]. [illegible] assessed the impact of [illegible] genetically-modified viruses [illegible] the environment of [illegible] arthropod. (D. A. Streett, [illegible] L. Snodgrass)

A study was conducted with the [illegible] Arkansas [illegible] the persistence of [illegible] nucleocapsid nucleopolyhedrovirus ([illegible]SNPV) [illegible] host plants [illegible] [illegible] *Heliothis virescens* [illegible] soybean (*Glycine max*) [illegible] *H. virescens* and cotton bollworm *H. zea*. [illegible] All virus treatments were [illegible] with > [illegible] soybean [illegible] on cotton [illegible] at [illegible] post-application at the highest [illegible] application [illegible] on soybean [illegible] rapid [illegible] virus activity [illegible] 7 [illegible] post-application [illegible] original virus activity was [illegible] virus application [illegible]. [illegible] S. Y. Young)

A field cage study was initiated to evaluate the efficacy of two isolates of a genetically-modified virus for *H. virescens* against three commercially available treatments for the control of *H. virescens* [illegible] cotton. (D. A. Streett)

[illegible] to determine the retention of [illegible] and protein labels by *M. croceipes* wasps [illegible] field conditions. Wasps (<2 days old) [illegible] obtained from the SIMRU Insect [illegible] Facility and were provided with [illegible] and water *ad libitum*. A [illegible] [illegible] was used to mist wasps with [illegible] rabbit immunoglobulin (IgG) or [illegible] IgG. A third group of wasps was [illegible] with fluorescent pink [illegible] [illegible] wasps [illegible] released in [illegible] (according to the label) in [illegible] commercial soybean field. Live wasps were [illegible] up to 9 days after being caged. A [illegible] antibody sandwich ELISA was [illegible] on each live wasp collected from [illegible] with IgG-labeled insects. Wasps [illegible] from the dust treatment were [illegible] under a [illegible] for 1 minute and scored for [illegible] or absence of dust. Average high [illegible] air temperatures during the study [illegible] 36°C and 20°C, respectively. [illegible] (0.04") was recorded ca. 30 [illegible] after wasps were caged. Wasps did not [illegible] protein label beyond 1 day after [illegible]. However, Day-Glo dust had 100% [illegible] throughout the study. Clearly, [illegible] hurdles must be overcome before [illegible] can be used to study parasitoid [illegible] the Delta. (L. Williams)

[illegible]

[illegible] de Nemours & Co. has several [illegible]cally-modified baculoviruses [illegible] development that infect insect [illegible]. These genetically-[illegible] viruses could provide better [illegible] and other tactics to

B. *INDICATORS OF PROGRESS:*

1. <u>Publications</u> (Published, In Press, Accepted)

Abel, C. A. 1998. A new source of host-plant resistance to European corn borer and other maize pests. Proc. 53rd Corn & Sorg. Seed Res. Conf. (In Press).

Abel, C.A., and R. L. Wilson. 1998. The use of diverse plant species for increasing *Osmia cornifrons* (Hymenoptera: Megachilidae) in field cages. J. Kan. Entomol. Soc. 71:23-28.

Hardee, D. D., and L. C. Adams. 1998. Influence of timing of sprays for cotton aphid, pp. 1061-1064. Proc. Beltwide Cotton Prod. Conf.

Hardee, D. D., and G. A. Herzog. 1998. 51st Annual Conference Report on Cotton Insect Research and Control, pp. 877-903. Proc. Beltwide Cotton Prod. Conf.

Hardee, D. D., D. V. Sumerford, and L. C. Adams. 1998. *Bt* Cotton: Status of Heliothine resistance in the United States. Prod. World Cotton Research Conference 2, p. 206 (Abstract).

Hardee, D. D., M. R. Bell, and D. A. Streett. 1999. A review of area-wide management of *Helicoverpa* and *Heliothis* (Lepidoptera: Noctuidae) with pathogens (1987-1997). Southwest. Entomol. (In Press).

Hardee, D. D., G. D. Jones, and L. C. Adams. 1999. Emergence, movement, and host plants of boll weevils (Coleoptera; Curculionidae) in the Delta of Mississippi. J. Econ. Entomol. (In Press).

Holloway, J. W., B. R. Leonard, J. A. Ottea, J. H. Pankey, J. B. Graves, and G. L. Snodgrass. 1998. Insecticide resistance and synergism of pyrethroid toxicity in the tarnished plant bug, *Lygus lineolaris*, pp. 947-949. In Proc. Beltwide Cotton Prod. Conf.

Jones, G. D., D. D. Hardee, and J. R. Coppedge. 1998. Early season foraging resources of Mississippi boll weevils, pp. 1009-1011. Proc. Beltwide Cotton Prod. Conf.

Jones, W. A. and G. L. Snodgrass. 1998. Development and fecundity of *Deraeocoris nebulosus* (Heteroptera: Miridae) on *Benisia argentifolii* (Homoptera: Aleyrodidae). Fla. Entomol. 81:345-350.

McKibben, G. H., P. A. Hedin, E. J. Villavaso, T. L. Wagner, and D. A. Dollar. 1998. How do boll weevils locate overwintering sites?, pp. 1015-1016. Proc. Beltwide Cotton Prod. Conf.

Luttrell, R. G., G. L. Snodgrass, and S. D. Stewart. 1998. Susceptibility management of the tarnished plant bug in the south, pp. 951-955. Proc. Beltwide Cotton Prod. Conf.

O'Neill, K. M., Woods, S. A., and Streett, D. A. 1997. Grasshopper (Orthoptera: Acrididae) foraging on grasshopper feces: observational and rubidium-labeling studies. Environ. Entomol. 26: 1224:1231.

Prior, C., and Streett, D. A. 1997. Strategies for the use of entomopathogens in the control of the desert locust and other Acridoid pests. Memoirs of the Entomological Society of Canada. 171:5-25.

[illegible]S IN PROGRESS:

[illegible]ing Published, In Press, [illegible])

[illegible] C. A. 1998. A new source of host-plant [illegible] European corn borer and other [illegible]. Proc. 53rd Corn & Sorg. Res. Conf. (In Press).

[illegible] Wilson. 1998. The [illegible] for increasing [illegible] [illegible] Miridae) in [illegible] J. Kan. Entomol. Soc. 71:23-28.

[illegible], L. D., and L. C. Adams. 1998. [illegible] of [illegible] of oviposition of tarnished [illegible] 1061-1064. [illegible] Beltwide Cotton Prod [illegible]

[illegible], D. C., and G. A. Herzog. 1998. 51st [illegible] Report on Cotton Insect [illegible] Control, pp. 8[illegible]-903. Proc. [illegible] Cotton Prod. Conf.

[illegible] D., D. V. Sumerford, and L. C. [illegible] 1998. Cotton: Status of [illegible] resistance in the [illegible] States. [illegible] Cotton Research C[illegible] 2, [illegible])

[illegible] D., M. [illegible] Bell and D. A. [illegible]. [illegible] of area-wide management of [illegible] and Heliothis (Lepidoptera: [illegible]) with pathogens (1987-1[illegible] [illegible] (In Press).

[illegible] and L. C. Adam[illegible] [illegible] environment, and host plan[illegible] [illegible] (Curculionidae) [illegible] [illegible]. J. Econ. Entomol.

Holloway, J. W., R. B. Leonard, J. A. Ottea, J. H. Pankey, J. [illegible] Graves, and S. L. Micinski. 1998. Insecticide resistance and synergism of pyrethroid toxicity in the tarnished plant bug, *Lygus lineolaris*, pp. 947-949. In Proc. Beltwide Cotton Prod. Conf.

Jones, G. D., D. D. Hardee, and J. R. Coppedge. 1998. Early season foraging resources of Mississippi boll weevils, pp. 1009-1011. Proc. Beltwide Cotton Prod. Conf.

Jones, W. A., and G. L. Snodgrass. 1998. Development and fecundity of [illegible] *nebulosus* (Heteroptera: Miridae) on *Bemisia argentifolii* (Homoptera: Aleyrodidae). Fla. Entomol. 81:345-350.

McKibben, G. H., P. A. Hedin, E. J. Villavaso, J. L. Wagner, and E. A. Parker. 1998. How far boll weevils locate overwintering sites?, pp. 1015-1016. Proc. Beltwide Cotton Prod. Conf.

[illegible]ard, R. G., G. L. Snodgrass, and S. D. Stewart. 1998. Susceptibility among areas of the tarnished plant bug in the south, pp. 9[illegible]-953. Proc. Beltwide Cotton Prod. Conf.

O'Neil, K. M., Woods, S. A., and Streett, D. A. 1997. Grasshopper (Orthoptera: Acrididae) foraging on grasshopper feces: observational and rubidium-labeling studies. Environ. Entomol. 26: 1224-1[illegible].

Prior, C., and Streett, D. A. 1997. Strategies for the use of entomopathogens in the control of the desert locust and other Acridoid pests. Memoirs of the Entomological Society of [illegible]ada. 171:5-25.

Scott, W. P., and G. L. Snodgrass. 1998. Response of male tarnished plant bugs to traps baited with different numbers of virgin females, pp. 1190-1192. Proc. Beltwide Cotton Prod. Conf.

Scott, W. P. and G. L. Snodgrass. Laboratory evaluation of insecticides to boll weevils at different ages, 1997. Arthropod Management Tests (Submitted Sept. 1998).

Scott, W. P. and G. L. Snodgrass. Laboratory evaluation of insecticides to boll weevils. Arthropod Management Tests (Submitted Sept. 1998).

Scott, W. P. and G. L. Snodgrass. Laboratory evaluation of susceptible tarnished plant bug tolerance to insecticides. Arthropod Management Tests (Submitted Sept. 1998).

Scott, W. P. and G. L. Snodgrass. Laboratory evaluation of field collected plant bug tolerance to insecticides. Arthropod Management Tests (Submitted Sept. 1998).

Scott, W. P. and G. L. Snodgrass. Response of tarnished plant bugs (Heteroptera: Miridae) to traps baited with virgin males or females. J. Econ. Entomol. (Submitted Sept. 1998).

Snodgrass, G. L., and W. P Scott. Seasonal changes in pyrethroid resistance over a three-year period in tarnished plant bug (Heteroptera: Miridae) populations in the Delta of Arkansas, Louisiana, and Mississippi. J. Econ. Entomol. (Submitted May 1998).

Snodgrass, G. L. and W. P. Scott. Laboratory evaluation of pyrethroid resistant tarnished plant bug tolerance to insecticides in 1997. Arthropod Management Tests (Submitted Sept. 1998).

Streett, D. A., M. R. Bell, and D. D. Hardee. 1998. Evaluation of the area-wide budworm/bollworm management program in the Mississippi Delta, pp. 1232-1235. Proc. Beltwide Cotton Prod. Conf.

Streett, D. A., M. R. Bell, and D. D. Hardee. 1998. Update on the area-wide budworm/bollworm management program with virus in the United States. Proc. World Cotton Research Conference 2, p. 194 (Abstract).

Streett, D. A., D. Davis, N. Van Beek. 1999. In vivo production of two recombinant viruses. J. Invertebr. Pathol. (In Press).

Streett, D. A., Bell, M. R., Hardee, D. D. 1999. Evaluation of early season nuclear polyhedrovirus treatment in an area-wide management program of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae). Southwest Entomol. (In Press).

Sumerford, D. V., W. G. Abrahamson, and A. E. Weiss. The effects of drought in the *Solidago altissima - Eurosta solidaginis* - natural enemy complex: Population dynamics, local extirpations, and measures of selection intensity on gall size. Oecologia (Accepted).

Villavaso, E. J., W. L. McGovern, T. L. Wagner, and J. L. Willers. 1998. Components of competitiveness in sterile male boll weevils (Coleoptera: Curculionidae). J. Econ. Entomol. 91: 631-636.

Villavaso, E. J., W. L. McGovern, and T. L. Wagner. 1998. Efficacy of bait sticks versus pheromone traps for removing boll weevils (Coleoptera: Curculionidae) from released populations. J. Econ. Entomol. 91: 637-640.

Stewart, D. A., M. R. Bell, and D. D. Hardee. 1998. Evaluation of the area-wide [illegible] bollworm management [illegible] in the Mississippi Delta, pp. 1293-1295. Proc. Beltwide Cotton Prod. Conf.

Street, D. A., M. R. Bell, and D. D. Hardee. 1998. Update on the area-wide budworm/bollworm management program with viruses in the United States. Proc. [illegible] Cotton Research Conference [illegible] p. [illegible] (abstract)

Street, D. A., D. Dunis, N. Van Beek. 1998. In vivo production of two recombinant viruses. J. Invertebr. Pathol. (In Press)

Street, D. A., Bell, M. R., Hardee, D. D. 1998. Evaluation of early season [illegible] polyhedrovirus treatment in an area-wide management program of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae). Southwest. Entomol. (In Press)

Sumerford, D. V., W. G. Abrahamson, and A. E. Weis. The effects of drought on the *Solidago altissima* - *Eurosta solidaginis* - natural enemy complex: Population dynamics, local extirpations, and measures of selection intensity on gall size. Oecologia (Accepted).

Villavaso, E. J., W. L. McGovern, T. L. Wagner, and J. [illegible] Willers. 1998. Components of competitiveness in sterile male boll weevils (Coleoptera: Curculionidae). J. Econ. Entomol. 91: 631-636

Villavaso, E. J., W. L. McGovern, and T. L. W[illegible]. 1998. Efficacy of bait sticks [illegible] traps for removing boll [illegible] (Coleoptera: Curculionidae) from [illegible] populations. J. Econ. Entomol.

[illegible] W. P., and G. L. Snodgrass. 1998. [illegible] of male tarnished plant bugs to traps [illegible] with different numbers of virgin [illegible]les, pp. 1190-1192. Proc. Beltwide [illegible] Prod. [illegible]

[illegible] P. and G. L. Snodgrass. Laboratory [illegible] of insecticides to boll weevils at [illegible] stages, 1997. Arthropod Management [illegible] (Submitted Sept. 1998)

[illegible] Snodgrass. Laboratory [illegible] of insecticides to boll weevils. [illegible] Management Tests (Submitted [illegible]

[illegible] W. P. and G. L. Snodgrass. Laboratory [illegible] of susceptible tarnished plant bug [illegible] to insecticides. Arthropod [illegible] Tests (Submitted Sept. 1998).

[illegible] W. P. and G. L. Snodgrass. Laboratory [illegible] of field collected plant bug [illegible] to insecticides. Arthropod [illegible] Tests (Submitted Sept. 1998).

[illegible] W. P. and G. L. Snodgrass. Response [illegible] plant bugs (Heteroptera: Miridae) [illegible] with virgin females or females. [illegible] (Submitted Sept. 1998).

Wagner, T. L., and Villavaso, E. J. Diapause in the boll weevil (Coleoptera: Curculionidae): Seasonal occurrence in Mississippi populations. Ann. Entomol. Soc. Am. (Accepted 7/28/98).

Wagner, T.L., and Villavaso, E. J. Effects of temperature and adult diet on development of hypertrophied fat body in prediapausing boll weevil. Ann. Entomol. Soc. Am. (Accepted 9/9/98).

Wagner, T. L., Villavaso, E. J., and Willers, J. L. Diapause in the boll weevil (Coleoptera: Curculionidae): Life-stage sensitivity to environmental cues. Ann. Entomol. Soc. Am. (Accepted 9/20/98).

Williams, L., III, D. J. Schotzko, and L. E. O'Keeffe. 1998. Herbivory, seed priming, and tillage systems: impacts on the growth response of *Pisum sativum* L. J. Entomol. Sci. 33: 196-211.

Williams, L., III, T. J. Dennehy, and J. C. Palumbo. 1998. Can resistance to chloronicotinyl insecticides be averted in Arizona field crops?, pp. 1250-1255. Proc. Beltwide Cotton Prod. Conf.

Wilson, R. L., C. A. Abel, and S. G. McClurg. 1999. Osmia spp. reared in artificial nesting sites in a backyard environment. Iowa Acad. Sci. (In Press).

Wilson, R. L., C. A. Abel, and R. L. Luhman. 1999. Comparing three bee species for controlled pollination of selected Brassicaceae. Iowa Acad. Sci. (In Press).

Woods, S. A., O'Neill, K. M., and Streett, D. A. 1997. Scavenging behavior of rangeland grasshoppers (Orthoptera: Acrididae): rubidium-label studies. Environ. Entomol. 26:789-796.

2. <u>In Manuscript</u>:

Abel, C. A., and R. L. Wilson. Evaluation of 11 maize populations from Peru for mechanisms of resistance to leaf feeding by European corn borer. J. Kansas Entomol. Soc. (In Preparation)

Abel, C. A., R. L. Wilson, and R. Luhman. Pollinating efficacy of *Osmia cornifrons* and *Osmia lignaria* (Hymenoptera: Megachilidae) on three *Brassicacea spp.* grown under field cages. J. Kansas Entomol. Soc. (In Preparation)

Abel, C. A., W. Salhuana, L. M. Pollak, M. P. Widrlechner, R. L. Wilson, and M. A. Berhow. Introgression of a novel source of resistance to European corn borer into two U. S. Corn Belt elite inbred lines. Crop Sci. (In Preparation)

Abel, C. A., R. L. Wilson, B. R. Wiseman, W. H. White, B. F. Binder, and M. A. Berhow. Evaluation of 15 experimental lines of maize for resistance to multiple insect pests. J. Econ. Entomol. (In Preparation)

Abel, C. A., W. Salhuana, L. M. Pollak, M. P. Widrlechner, and R. L. Wilson. Registration of 6 experimental lines of maize resistant to European corn borer. Crop Sci. (In Preparation).

Abel, C. A., R. L. Wilson, L. M. Pollak, and W. Salhuana. Registration of 5 experimental lines of maize resistant to multiple insects. Crop Sci. (In Preparation)

Bryan, W. W., D. A. Herbert, Jr., and D. D. Hardee. Three methods of exposing host larvae for oviposition at three different host densities for disease incidence and rearing success of *Microplitis croceipes*. J. Entomol. Sci. (In Preparation).

Dennehy, T. J. and L. Williams, III. Bioassay development, and baseline susceptibility of Arizona populations of *Bemisia argentifolii* to imidacloprid. J. Econ. Entomol. (In Preparation).

Hardee, D. D., and L. C. Adams. Influence of timing of sprays for cotton aphid (Homoptera: Aphididae) on cotton yield. J. Econ. Entomol. (In Preparation).

Hardee, D. D., L. C. Adams, D. A. Adams, and D. W. Hubbard. Effect of severity of winter on emergence and development of populations of bollworm/tobacco budworm (Lepidoptera: Noctuidae). J. Econ. Entomol. (In Preparation).

Martinson, T. E., L. Williams, III, and G. English-Loeb. Compatibility of chemical disease and insect management practices used in New York vineyards with biological control by *Anagrus* spp. (Hymenoptera: Mymaridae) a parasitoid of *Erythroneura* leafhoppers. Biol. Control. (In preparation).

Scott, W. P., and G. L. Snodgrass. Two year evaluation of Regent on tarnished plant bug populations in small plot and large plot EUP tests. J. Cotton Science (In Preparation).

Snodgrass, G. L. A red-eyed mutant of the tarnished plant bug (Heteroptera: Miridae): Natural occurrence and inheritance of the trait. Annals Entomol. Soc. Amer. (In Preparation).

Sumerford, D. V. Effects of sub-lethal doses of CryIA(c) on the developmental rate of *Helicoverpa zea* (Boddie). Environ. Entomol. (In Preparation).

Sumerford, D. V. Method to monitor tolerance of *Bt* toxins for *Helicoverpa zea* (Lepidoptera: Noctuidae). Entomol. Exp. Appl. (In Preparation).

Sumerford, D. V., L. C. Adams, and D. D. Hardee. Baseline levels of tolerance to CryIA(c) in field populations of *Helicoverpa zea* (Boddie) and *Heliothis virescens* (F.): Two years of data. J. Econ. Entomol. (In Preparation).

Sumerford, D. V., and W. L. Solomon. Levels of genetic variation for tolerance to CryIA(c) in field populations of *Helicoverpa zea* (Boddie) and *Heliothis virescens* (F.) J. Econ. Entomol. (In Preparation).

Sumerford, D. V., D. D. Hardee, L. C. Adams, and W. L. Solomon. Status of monitoring for tolerance to CryIA(c) in populations of *Helicoverpa zea* and *Heliothis virescens*: Three year summary. Proc. 1999 Beltwide Cotton Prod. Conf. (In Preparation).

Sumerford, D. V., W. L. Solomon, L. C. Adams, and D. D. Hardee. Monitoring for resistance to CryIA(c) in populations of tobacco budworm and cotton bollworm: summer of 1998. Proc. 1999 Beltwide Cotton Prod. Conf. (In Preparation).

Villavaso, E. J., J. E. Mulrooney, T. L. Wagner, W. L. McGovern, and J. L. Willers, Efficacy of mist blowers in dispersing malathion over the perimeters of cotton fields and mortality of boll weevils (Coleoptera: Curculionidae) exposed to

treated leaves. (submitted to J. Cotton Sci. 6/17/98).

Villavaso, E. J., J. E. Mulrooney, T. L. Wagner, W. L. McGovern, and K. Howard. Aerial and ground application of malathion for boll weevil control. J. Econ. Entomol. (In Preparation).

Wagner, T. L., and E. J. Villavaso. Respiration rates of reproductive and diapausing boll weevils. Proc. Beltwide Cotton Prod. Conf. (In Preparation).

Williams, L., III and T. E. Martinson. Colonization of New York vineyards by *Anagrus* spp. (Hymenoptera: Mymaridae): overwintering biology, within-vineyard distribution of wasps, and parasitism of grape leafhopper, *Erythroneura* spp. eggs. Biol. Control. (In Preparation).

Williams, L., III and N. P. Tugwell. Histological description of tarnished plant bug, *Lygus lineolaris*, feeding on small cotton floral buds. J. Entomol. Sci. (In Preparation).

Williams, L., III, T. J. Dennehy, and J. C. Palumbo. Whitefly, *Bemisia argentifolii*, resistance to chloronicotinyl insecticides in the intensive vegetable-melon-cotton production systems of Arizona. J. Econ. Entomol. (In Preparation).

Williams, L., III and J. P. McCaffrey. The spider (Araneae) fauna of green peas, *Pisum sativum* L., in eastern Washington and Oregon. Environ. Entomol. (In Preparation).

3. <u>Presentations</u>:

Abel, C. A. "Alternative Pollinators," Iowa Fruit and Vegetable Growers Association Annual Meeting, Des Moines, IA, February 1998. (Invitation)

Abel, C. A., and R. L. Wilson. "European corn borer resistant maize from Peru," Internat. Plant Resist. Ins., 13th Biennial Workshop 13:1. Memphis, TN, March 1998.

Abel, C. A., and R. L. Wilson. "A new source of maize resistance to European corn borer," 1998 ESA/APS Joint Annual Meeting. #160. Las Vegas, NV, November 1998.

Abel, C. A., "A new source of host-plant resistance to European corn borer and some other pests of maize," 53rd Corn and Sorghum Research Conference of the American Seed Trade Association, Chicago, IL, December 1998. (Invitation)

Hardee, D. D., and L. C. Adams. "Influence of timing of sprays for cotton aphid," Beltwide Cotton Production Conferences, San Diego, CA, January 1998.

Hardee, D. D. "Review of USDA-ARS Insect Research at Stoneville," 25th Meeting of Mississippi Agricultural Consultants Association, Mississippi State, MS, February 1998 (Invitation).

Hardee, D. D. "Cotton aphid: biology, control, and impact on yield," Advanced Cotton Pest Management Short Course, Mississippi State, MS, March 1998 (Invitation).

Hardee, D. D., D. V. Sumerford, and L. C. Adams. "*Bt* cotton: Status of *Heliothis* resistance in the United States," World Cotton Research Conference-2, Athens, Greece, September 1998.

Hardee, D. D. "Influence of transgenic crops on insect control," Mississippi Agron. Prof. Continuing Education Workshop, Mississippi State, MS, October 1998 (Invitation).

Hardee, D. D. "Overview of ARS boll weevil research in Mississippi," ARS Boll Weevil Research Review, College Station, TX, October 1998 (Invitation).

Hardee, D. D. "Entomology in a new era: Our changing roles (research)," 45th Annual Mississippi Insect Control Conference, Mississippi State, MS, November 1998 (Invitation).

Scott, W. P., and G. L. Snodgrass. "Response of male tarnished plant bugs to traps baited with different numbers of virgin females," Beltwide Cotton Production Conferences, San Diego, CA, January 1998 (presented by Larry Adams)

Scott, W. P. "Role of temik in cotton production and update of Regent EUP trials in Mississippi," Rhone Poulenc LA/MS Technical Conference, Vicksburg, MS, January 1998.

Scott, W. P. "Tarnished plant bug resistance, resistance management, and efficacy trials," Advanced Cotton Insect Management Short Course, Mississippi State University, Mississippi State, MS, March 1998.

Snodgrass, G. L. "Status of resistance in *Lygus lineolaris* in the south," Beltwide Cotton Production Conferences, San Diego, CA, January 1998.

Snodgrass, G. L. "Tarnished plant bugs and their resistance to insecticides," 25th Annual Delta Ag Expo, Cleveland, MS, January 1998.

Snodgrass, G. L. "Insecticide resistant plant bugs: extent of problem and options for management," Joint meeting of Mississippi Agricultural Pest Management Association, Greenville, MS, February 1998.

Snodgrass, G. L. "Inheritance of a red-eyed mutation in the tarnished plant bug.," Southeastern Branch Meeting ESA, Chattanooga, TN (Poster). March 1998.

Snodgrass, G. L., W. P. Scott, J. Robbins, and D. D. Hardee. "Adaptation of the tarnished plant bugs to agricultural changes in the Mississippi Delta," 45th Annual Mississippi Insect Control Conference, Mississippi State, MS, November 1998.

Streett, D. A. M. R. Bell, and D. D. Hardee. "Evaluation of the area-wide budworm/bollworm management program with virus in the Mississippi Delta," Beltwide Cotton Production Conferences, San Diego, CA, January 1998.

Streett, D. A., M. R. Bell, and D. D. Hardee. "Update on the area-wide budworm/bollworm management program with virus in the United States," World Cotton Conference-2, Athens, Greece, September 1998.

Streett, D. A., G. W. Felton, and S. Y. Young. "Persistence of a nucleopolyhedrosis virus on plant surfaces," Entomological Society of America National Meeting, Las Vegas, NV, November, 1998 (poster).

Villavaso, E. J., W. L. McGovern, T. L. Wagner, J. L. Willers, and J. E. Mulrooney. "Boll weevil mortality following perimeter treatments of cotton field with ULV malathion". SERA-IEG Meeting, Chattanooga, TN, March 1998.

Snodgrass, G. L. "Insecticide resistant plant bugs, extent of problem and options for management," Joint meeting of Mississippi Agricultural Pest Management Association, Greenville, MS, February 1998.

Snodgrass, G. L. "Inheritance of a male-eyed mutation in the tarnished plant bug," Southeastern Branch Meeting ESA Chattanooga TN (Poster) March 1998.

Snodgrass G. L., W. P. Scott, J. D. ... and D. D. Hardee. "Adaptation of the tarnished plant bugs to agricultural changes in the Mississippi Delta," 46th Annual Mississippi Insect Control Conference, Mississippi State, MS, November 1998.

Streett, D. A., M. R. Bell, and D. D. Hardee. "Evaluation of the area-wide budworm/bollworm management program with virus in the Mississippi Delta," Beltwide Cotton Production Conferences, San Diego, CA, January 1998.

Streett, D. A., M. R. Bell, and D. D. Hardee. "Update on the area-wide budworm/bollworm management program with virus in the United States," World Cotton Conference-2, Athens, Greece, September 1998.

Streett, D. A., G. W. Felton, and S. Y. Young. "Persistence of a nucleopolyhedrosis virus on plant surfaces," Entomological Society of America National Meeting, Las Vegas, NV, November 1998 (poster).

Villavaso, E. J., W. L. McGovern, T. L. Wagner, L. Walters, and J. E. Mulrooney. "Boll weevil mortality following perimeter treatment of cotton field with ULV malathion". SERA-IEG Meeting, Chattanooga TN, March 1998.

...effects of transgenic crops ...," Mississippi Agron. Prof. ... Workshop, Mississippi ... 1998 (Invitation).

..., D. L. "Overview of ARS boll weevil research in Mississippi," ARS Boll Weevil Research Review, College Station, TX, ...ber 1998 (Invitation).

... "... Entomology in a new era: the ... roles of research)," 45th Annual Mississippi Insect Control Conference, Mississippi State, MS, November 1998 (Invitation).

..., W. P., and G. L. Snodgrass. "Response of ... tarnished plant bugs to traps baited ... different numbers of virgin females," Beltwide Cotton Production Conferences, San Diego, CA, January 1998 (presented by Larry ...).

..., W. P. "Role of Intruder in cotton ... production and ... of Bayer El Trials in Mississippi," Rhone Poulenc LA/MS ... Conference, Vicksburg, MS, ...

... 5th Annual ... MS, January 1998.

Villavaso, E. J. Invited to train Field-Unit Supervisors, Southeastern Boll Weevil Eradication Foundation, in aspects of boll weevil diapause, effectiveness of malathion, and scheduling diapause treatments. Mississippi State, MS, March 1998.

Wagner, T. L. Invited to train Field-Unit Supervisors, Southeastern Boll Weevil Eradication Foundation: aspects of boll weevil diapause and scheduling diapause treatments, Mississippi State, MS, March 1998.

Wagner, T. L. Participated in the Boll Weevil 5-Year Research & Action Plan Meeting to review and update ARS research directed at this pest. Presented talks on boll weevil diapause, models predicting diapause control spray intervals, and ULV malathion research. College Station TX, October 1998.

Williams, L., III, T. J. Dennehy, and J. C. Palumbo. "Can resistance to chloronicotinyl insecticides be averted in Arizona field crops?" Beltwide Cotton Production Conferences, San Diego, CA, January 1998.

Williams, L., III. "Biological control of cotton insect pests in the Mississippi Delta," Entomological Society of America National Meeting, Las Vegas, NV, November, 1998.

Williams, L., III. "Natural history of a multitrophic association in Baja California, México," Entomological Society of America National Meeting, Section Symposia A2: Entomodiversity of the Baja California Peninsula, México, Las Vegas, NV, November, 1998. (Invitation).

IV. PLANNED RESEARCH CALENDAR YEAR 1999:

A. *NARRATIVE:*

1. <u>In-House</u>

Mapping of quantitative trait loci affecting soybean resistance to leaf-feeding insects via genetic maps created from RAPD markers will be initiated. **(C. Abel, D. V. Sumerford)**

Experimental lines of maize with a high expression of Peruvian maize resistance to leaf and stalk feeding European corn borer will be evaluated for resistance to southwestern corn borer, western corn rootworm, European corn borer oviposition, and corn leaf aphid. **(C. A. Abel, F. M. Davis, B. F. Binder, B. Hibbard)**

Experimental lines of maize with a high expression of Peruvian maize resistance to leaf and stalk feeding European corn borer will be grown in isolation plots under selection pressure from multiple maize pests. Two cycles of recurrent selection and subsequent inbreeding will be used to develop multiple pest resistant maize experimental lines and inbred lines. **(C. A. Abel, F. M. Davis)**

The causative agent of resistance for Peruvian maize resistant to leaf feeding by European corn borer will be identified. **(C. A. Abel, M. A. Berhow, R. L. Wilson)**

The mechanism of resistance to soybean looper and velvetbean caterpillar will be determined for 5 soybean Plant Introductions resistant in the field to leaf-feeding insects. **(C. A. Abel, T. C. Kilen)**

Soybean Plant Introductions with different mechanisms of resistance to leaf feeding insects will be crossed to develop an improved 'Lamar'-type variety. Genome mapping techniques will be used to identify resistant trait loci in order to improve selection for multiple mechanism resistance. **(C. A. Abel, T. C. Kilen, D. V. Sumerford)**

The possible reproduction of the tarnished plant bug on maize will be monitored. **(C. A. Abel, G. L. Snodgrass)**

The Stoneville Insect Rearing Research Support Group will continue to maintain seven insect species in 1999. These will include: tobacco budworm, bollworm, soybean looper, beet armyworm, velvetbean caterpillar, *Cardiochiles nigriceps,* and *Microplitis croceipes*. Assistance will be given to individual scientists in maintaining insects needed for their research. Artificial diet will be supplied in 30-ml plastic cups and 3.8 liter multicellular trays. Efforts will continue to develop lidding for disposable multicellular larval rearing trays (consider the unit trays with cellular covering). The training in insect rearing techniques and the transfer of technology provided by industry will continue. As always, efforts will continue to produce high quality insects at the most economical price possible. The research

determined in 5 genes. Plant Introductions resistant in the field to leaf-feeding insects. (C. A. Abel, F. C. Hale)

Soybean Plant Introductions will mechanisms of resistance to leaf feeding insects will be used to develop an improved 'Lamar'-type variety. Genome mapping techniques will be used to identify resistant trait loci in order to improve selection for multiple mechanism resistance. (C. A. Abel, . Nilan, D. V. Summerford)

The possible reproduction of the tarnished plant bug on maize will be monitored. (C. A. Abel, G. L. Snodgrass)

The Stoneville Insect Rearing Research Support Group will continue to maintain seven insect species in 1990. These will include: tobacco budworm, bollworm, soybean looper, beet armyworm, velvetbean caterpillar, *Cardiochiles nigriceps* and *Microplitis croceipes*. Assistance will be given to individual scientists in maintaining insects needed for their research. Artificial diet will be supplied in 30-ml plastic cups and 3.8 liter multicellular trays. Efforts will continue to develop lidding for disposable multicellular larval rearing trays (consider the unit trays with cellular covering). The training in insect rearing techniques and the transfer of technology provided by industry will continue. As always efforts will continue to produce high quality insects at the most economical price possible. The research

g e trait loci affecting ce of resistance to leaf-feeding insects via dle created from RAPD markers inui (C. bel, D. V. Summerford)

ural lines of maize with a high n of Peruvian maize resistance to feeding European corn borer evaluated for resistance to hwestern corn borer, western corn orm, European corn borer oviposition, corn leaf aphid. (C. A. Abel, Davis, F. Bender, B Hibbard)

rimental lines of maize with a high ession of Peruvian maize resistance to alk feeding European corn borer under

noon

be

of approximately 150 scientists within USDA-ARS, private industry, and state universities will be supported by the work of this unit. **(R. L. Ford)**

Greenhouse and laboratory studies on effect of aldicarb on cotton aphid resistance to insecticides will be expanded to verify previous conclusions. **(D. D. Hardee, L. C. Adams)**

Any new boll weevil attract-and-kill devices supplied by commercial companies will be evaluated to determine their effectiveness in comparison with commercially available devices and traps. In addition, studies in cooperation with the Mississippi Boll Weevil Management Corporation will be initiated wit the BWACT® system to determine if these devices can be substituted for malathion sprays near beeyards. **(D. D. Hardee, E. J. Villavaso, W. L. McGovern, L. C. Adams)**

A 4th year of a study of influence of cotton aphids on ultimate yields of cotton by spraying cotton twice beginning prior to squaring, at first ⅓-grown square, and at first bloom will be repeated using transgenic and nectariless varieties of cotton. **(D. D. Hardee, L. C. Adams)**

Monitoring of resistance to *Bt* products and transgenic cotton to cotton bollworms and tobacco budworms will be greatly expanded and will include colonies of these insects collected in *Bt* cotton, non-*Bt* cotton, and corn from as many areas as possible across the Cotton Belt. In addition, personnel will be sent to areas of high *Bt* cotton acreage and 4th-year *Bt* cotton plantings to collect large numbers of bollworms/budworms in *Bt* and non-*Bt* cotton and corn. These studies will include applications of MVP II insecticide to cotton in a spray chamber, as well as MVP II, CryIA(c) protein (from *Bt* cotton) and CryIA(b) protein (from *Bt* corn) incorporated into diet. The objective will be to determine susceptibility levels for possible detection of beginning tolerance or resistance in the field to these products. **(D. D. Hardee, D. V. Sumerford, L. C. Adams, W. L. Solomon)**

Evaluations of UNR and conventional cotton will be continued to detect any differences in insect conditions in the two systems. **(D. D. Hardee, L. C. Adams, in cooperation with the Southern Weed Science Research Unit)**

New and promising proprietary insecticides will be evaluated against designated cotton insects as deemed appropriate. **(D. D. Hardee, L. C. Adams, in cooperation with private industry)**

Monitoring of successive generations of bollworm/budworm for tolerance to five insecticide classes will be continued. **(D. D. Hardee, L. C. Adams)**

Trap surveys for boll weevil, beet armyworm, bollworm, and tobacco budworm will be repeated. **(D. D. Hardee, L. C. Adams, D. W. Hubbard)**

Studies will continue on 16 farms throughout the Mississippi Delta that grow *Bt* and non-*Bt* cotton varieties. In cooperation with Delta Research and Extension Center, an entomological and economic evaluation of both plantings will be conducted for the second year on each farm. Yields will be taken from large plots; data on gin lint turnout will be obtained. **(W. P. Scott, G. L. Snodgrass, F. T. Cooke)**

Laboratory bioassays and small field plots will be used to continue year-to-year evaluations of new insecticides from industry. **(W. P. Scott, G. L. Snodgrass, D. A. Adams)**

Regent, CGA2933, and other products that cold be close to registration will be evaluated in "crop destruct" large field plots. Target pests will be tarnished plant bugs and boll weevils. **(W. P. Scott, G. L. Snodgrass, D. A. Adams)**

Insecticide resistance in the tarnished plant bug will continue to be investigated. A study performed in 1998 that determined resistance to Orthene at 20 locations in the Delta in August will be repeated. **(G. L. Snodgrass, W. P. Scott)**

A large experiment on areawide control of plant bugs in cotton by destruction of early season wild host plants will be repeated in 1999. Changes from 1998 will include earlier treatment (March) of wild hosts, sampling of corn fields, and if possible, expanding the number of treated areas from 1 to 2. **(G. L. Snodgrass, W. P. Scott, D. D. Hardee)**

Studies on using a mutant red-eyed colony of tarnished plant bugs in movement studies will continue. Research will focus on rearing a large number of bugs (3-5,000) and feeding them blooms from the main wild host plant in the area of which they will be released to acclimate them to stay in the release area. Sampling of wild hosts will then be used to determine if they reproduce and spread from the release area. **(G. L. Snodgrass)**

Tarnished plant bug nymphs will be collected in non-agricultural areas of Mississippi. Part of the nymphs will be dissected to determine rates of parasitism (mainly braconid wasps), and the remaining nymphs will be reared to obtain adult parasitoids. **(G. L. Snodgrass, W. P. Scott)**

Studies begun in 1998 on reproductive diapause in tarnished plant bugs will continue in 1999. Objectives are to determine when reproductive diapause begins and ends, percentages of the population in diapause, egg production after diapause is broken, longevity of females after diapause, and sex ratios of adults during the year. **(G. L. Snodgrass)**

Research on the area-wide management program with *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) will continue to evaluate the impact of a lower virus application rate with a virus enhancing agent. **(D. A. Streett)**

Research will continue to evaluate the impact of genetically-modified viruses on non-target arthropods in a cotton field. **(D. A. Streett, G. L. Snodgrass)**

Research will be conducted to evaluate the impact of transgenic cotton on beet armyworm populations. The temporal and spatial distribution of insect pests on transgenic cotton will be monitored during the season. Transgenic gene expression in different plant parts will also be monitored during the season and under different environmental conditions. **(D. A. Streett)**

Collaborative research will be continued to assess field persistence of virus formulations on cotton. **(D. A. Streett, M. R. McGuire)**

Research will be continued to determine the impact of lower rates of the *Helicoverpa zea*

virus against *H. zea* on *Bt* cotton. **(D. A. Streett, J. Mulrooney)**

Genetic variability for tolerance of Cry I A(b) (*Bt* toxin expressed in transgenic corn) and Cry I A9c) (*Bt* toxin expressed in transgenic cotton) in field-collected populations of *Helicoverpa zea* will be examined using larvae and adults caught at light traps throughout the Mid-South area. These data will create baseline estimates of heritability of *Bt* resistance. **(D. V. Sumerford)**

Genetic variability for tolerance of Cry I A(c) (*Bt* toxin expressed in transgenic cotton) in field-collected populations of *Heliothis virescens* will be examined and compared to results from 1998. These data will create baseline estimates of heritability of *Bt* resistance. **(D. V. Sumerford)**

Studies will be set up to determine if the tolerance to *Bt* toxins affects the efficacy of conventional insecticides (and vice versa) for controlling *Helicoverpa zea*. **(D. V. Sumerford)**

Genomic mapping projects of *Heliothis virescens* and *Helicoverpa zea* will be started using RAPD markers. The genome maps will eventually be used to better understand the inheritance of *Bt* resistance, as well as identification of parents in questionable genetic crosses. **(D. V. Sumerford)**

Selection for tolerance of CryIA(c) in different colonies of *Helicoverpa zea* will continue. Eventually, these colonies and the RAPD genome map will be used to map quantitative-trait loci in order to better dissect the genetic mechanism(s) underlying *Bt* resistance in *Helicoverpa zea*. **(D. V. Sumerford)**

Population structure studies of *Helicoverpa zea* and *Heliothis virescens* in the Mid South and Southeast will be initiated. **(D. V. Sumerford)**

Research will continue on the feasibility of using aerial or ground treatment of localized, early-season boll weevil infestations in large cotton fields rather than whole field treatments for boll weevil eradication. **(E. J. Villavaso, W. L. McGovern, T. L. Wagner)**

Research is being initiated with IPM Technologies to establish the feasibility of using the attracticide, Sirene, as a component of boll weevil eradication. **(E. J. Villavaso, W. L. McGovern, T. L. Wagner)**

Research will continue on diapause termination and the effect of the cotton plant on the development of diapause characteristics. **(E. J. Villavaso, T. L. Wagner, W. L. McGovern)**

Research will continue on evaluating the effectiveness of pheromone technology on late-season boll weevil populations. **(E. J. Villavaso, T. L. Wagner, W. L. McGovern)**

Data collected during 1997-98 on boll weevil diapause will be analyzed, interpreted, and published. **(T. L. Wagner, E. J. Villavaso, W. L. McGovern)**

Investigations will continue on the effects of the host plant on boll weevil diapause induction. **(T. L. Wagner, E. J. Villavaso, W. L. McGovern)**

Investigation will continue on boll weevil diapause development and termination. **(T. L. Wagner, E. J. Villavaso, W. L. McGovern)**

The biology of *A. iole*, an indigenous egg parasitoid of *L. lineolaris* will continue to be studied in the Midsouth. The work will focus on elucidation of the wasp's overwintering strategy, and ecological interactions with *L. lineolaris* on wild weed hosts. **(L. Williams)**

Efforts will continue toward the establishment of a laboratory colony of *A. iole* indigenous to the Midsouth. Access to such a colony will facilitate future studies on the behavior and dispersal of the wasp, as well as insecticide residue investigations. **(L. Williams)**

A mark-release-recapture study will be conducted to determine dispersal of *L. lineolaris* in crop and non-crop hosts. Chemical labels used to mark *L. lineolaris* will also facilitate identification of *L. lineolaris* predators. **(L. Williams, G. L. Snodgrass)**

Investigations will continue on the effect of sub-lethal concentrations of insecticides on the perception of plant and host volatiles by parasitic wasps. **(L. Williams, W. van Giessen)**

Studies on the impact of refuges on parasitoid life history traits and on subsequent impact on cotton pests will be initiated. **(L. Williams)**

2. <u>Extramural</u>

The host plant can apparently have an effect on the efficacy of a microbial control agent. Research will be conducted using different cotton varieties to evaluate the inactivation of a baculovirus. **(D. A. Streett, G. Felton, S. Y. Young)**

Collaborative research will continue with E. I. Dupont de Nemours & Co to evaluate the field activity and field stability of several genetically-modified viruses in cotton. **(D. A. Streett, D.D. Hardee)**